CALIFORNIA GEOLOGICAL SURVEY
FAULT EVALUATION REPORT FER-248

# TIN MINE, MAIN STREET, EAGLE and GLEN IVY (NORTH AND SOUTH) FAULT STRANDS of the ELSINORE FAULT ZONE

Riverside County
California

by
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## INTRODUCTION

The Elsinore fault is one of the main right-lateral strike-slip faults in southern California, and is a part of the San Andreas family of faults (Figure 1). It was named by Lawson and others (1908). It extends southeastward from the Santa Ana River, in Riverside County, to south of the Mexican border and incorporates many named strands. Within the Corona South quadrangle are the Main Street, Tin Mine, Eagle, Glen Ivy North and Glen Ivy South fault strands of the Elsinore fault zone (Figure 2). Southwest of the city of Corona the Elsinore fault is joined by the Chino fault (evaluated separately in FER-247 by Treiman, 2002). The Main Street, Eagle and Tin Mine faults were named by Weber (1977); the Glen Ivy fault was named by Engle (1933) and the north and south strands were named by Jahns (1954).

The northern portion of the Elsinore fault zone was previously evaluated in Fault Evaluation Report 72 (Smith, 1978 & 1979) wherein zoning was recommended for the Main Street, Eagle and Glen Ivy strands. The purpose of this evaluation is to assess the need for revision of the existing Earthquake Fault Zone (EFZ) for the Elsinore fault on the Corona South quadrangle at this time when other revisions are being made on this quadrangle for the Chino fault (Treiman, 2002). The extension of the Tin Mine fault onto the Black Star Canyon quadrangle is also considered. These re-evaluations are based primarily on geologic reports for development subsequent to the previous evaluation and some additional aerial photo interpretation. Field work was not attempted, except as already done for the Chino fault evaluation and a visit to trenches excavated during the course of this evaluation. This report may be considered supplemental to Fault Evaluation Report 72.

## SUMMARY OF AVAILABLE DATA (Plate I)

This portion of the Elsinore fault zone has been mapped by Gray (1961) and more recently by Weber (1977) (Figure 2). Both of their work was considered in the previous Fault Evaluation (Smith, 1978 & 1979) that resulted in the fault's inclusion in Special Studies Zones (now Earthquake Fault Zones) in 1980. Fault related features identified by Weber (1977) are indicated on Plate I and summarized in Table 1. Woodward-Clyde Consultants (1980; summarized by Heath et al, 1982) made additional assessment of geomorphic features along the fault, in particular calling attention to several fault scarps (Plate I). A recently released digital geologic map of the Corona South quadrangle (Gray and others, 2002) shows most faults essentially as previously mapped by Weber (1977), except for revised mapping in the vicinity of the Tin Mine fault. In this area, another strand has been delineated and the entire structure associated with the Whittier fault. This strand diverges from that mapped by Weber (1977) south of Mabey Canyon (Plate I & Figure 3).

Several geotechnical studies have been done along the Elsinore fault zone since the previous evaluation (Table 2), and at least two of these have generated new data that warrant local re-evaluation of the current Alquist-Priolo Earthquake Fault Zone boundary. A study by Pacific Soils Engineering (1984; Plate I, site 10) found a strand of the Glen Ivy North fault extending beyond the current zone boundary. The fault, as exposed in their trench T-9 (see Plate I and Figure 4), juxtaposed Silverado Formation against estimated late-Quaternary terrace deposits. Although colluvial deposits are not shown as being faulted they are only logged on the downslope side of the fault, abruptly occurring as a 2-foot thick slope unit. Recent work by GeoSoils, Inc. (2002) at site 9 confirms the northwestern projection of this fault. The Glen Ivy North fault may be related to additional faults on trend at site 8, although it was not found in an intervening trench. (Also see discussion below of field observations at site 9/10).

At site 8, a series of studies culminating in a report by GeoSoils, Inc. (1997) identified several faults outside the current zone that were judged to be active by the consultants, based on the fault cutting the youngest surface colluvium at three trench locations, as well as work by prior consultants. This fault trace coincides with Weber's (1977) observation of faulted late-Quaternary (<100 ka) mudflow breccia (LQ-32). Construction setbacks were recommended for these faults, with final setbacks to be determined after grading (GeoSoils, Inc., 1997). Mapping by Weber (1977) and Gray and others (2002) in the vicinity of Bedford Canyon recorded a section of overturned bedding within sites 8 and 9 that is indicated on Plate 1 by selected structural symbols from those sources.

A series of studies at site 1 were instructive, in that the mapped fault location changed with each study but ultimately coincided (as mapped during grading) with features visible in the aerial photography. Based on cross-cutting relationships, and the apparent pre-Holocene age of the youngest of the faults (based on an overlying unfaulted older alluvial deposit with a "strongly developed soil profile"), all of the onsite faults were judged to be inactive (Neblett & Assoc., 2000).

The Tin Mine fault is also being reconsidered. In his review of available fault evidence, Smith (1979) was not impressed with the Tin Mine fault as mapped by Weber (1977) and felt there was not much indication of continuity or recency. Although there is no new published or field data, the aerial photos have been re-interpreted for this fault evaluation.

Studies across the Glen Ivy South fault (site 11) by GeoSoils, Inc. (1999) purported to demonstrate that, on this quadrangle, "the last movement of the Glen Ivy South fault occurred in pre-Holocene time, including any step-over faulting" and the consultants recommended deletion of this portion of the EFZ.

FIELD OBSERVATIONS

Several trenches across the northwest projection (pink trace on Plate I) of the Glen Ivy North fault at site 9/10 (GeoSoils, 2002) were inspected on July 16, 2002. Within one of these trenches a fault was observed that separated a normal section of undifferentiated Sespe-Vaqueros Formation (Tsv) from an overturned section (see photo below). The fault did not offset the overlying young to modern stream channel deposits. This fault coincides roughly with a concealed fault trace shown by Weber (1977). The overturned section of Tsv lies between the Glen Ivy North fault and the main strands (Eagle fault) of the Elsinore fault zone. Several other shear zones were observed in this overturned section, mostly along bedding planes.


Southeast wall of trench FT-12 exposed deformed and overturned beds on the right juxtaposed with gravel beds within a normally-bedded section on the left. Slickensides along the fault (N45° W, 60° SW) plunged gently to the southeast.

AERIAL PHOTO INTERPRETATION (Plate II)

*Tin Mine fault* The Tin Mine fault, as mapped by Weber (1977), has a fairly well-expressed trace on the Corona South quadrangle, indicated by aligned saddles, benches and linear drainages. Mabey Canyon, and the next canyon to the south, may be offset right-laterally more than 300 meters (locale B). A smaller drainage, just north of Tin Mine Canyon, may also be slightly offset. In contrast, the "Whittier" fault strand of Gray and others (2002), south of Mabey Canyon, does not have any geomorphic expression that would indicate recent activity.

The Tin Mine fault is also well expressed to the northwest, on the Black Star Canyon quadrangle (Figure 3), where it is marked by aligned saddles, linear drainages and deflected drainages comparable to those on the Corona South quadrangle. At Fresno Canyon (locale A) there is an older, now overfit, stream course that has been beheaded, perhaps in part due to faulting. However, the fault does not obviously affect a lower stream terrace in Fresno Canyon.

*Main Street fault* The Main Street fault is identified by prominent scarps and drainage offsets (locales D, E & F), in addition to various aligned saddles and linear drainages and beheaded drainages. Younger, shorter drainages are also offset, but to a lesser degree than the larger canyons. The northwesternmost extent of this fault (west of Hagador Canyon) is suggested by weak geomorphic features and a possible minor stream offset (locale C). Alternatively, the stream offset may be related to the more northerly trending fault mapped at site 1 (Neblett and Assoc., 2000). The expression of either of these northwestern fault splays is consistent with erosion along a pre-existing zone of weakness.

*Eagle fault* The trace of the Eagle fault is indicated by breaks in slope, scarps, and aligned saddles. The southern margin of Bedford Canyon may be offset (locale H), and a small bedrock ridge just to the south is clearly offset right-laterally. However, the northwestern portion of the Eagle fault, as it veers westward from the Main Street fault, has a less youthful expression and does not appear to affect the younger drainages (locale G).

*Glen Ivy North fault* The Glen Ivy North fault is prominently expressed by scarps and offset drainages at Temescal Valley. To the northwest it is marked by increasingly more subtle expression, although it may control the southeasterly flowing segment of McBribe Canyon (locale I). Northwest of Bedford Canyon the fault trace (as located by consultants) may be indicated by a few subtle benches and possible greater erosion of some drainages upstream from the fault.

*Glen Ivy South fault* The Glen Ivy South fault is only minimally expressed on the Corona South quadrangle, but is indicated by the northwestern end of a scarp that is better expressed to the southeast, on the Lake Mathews quadrangle. There is a suggestion in the aerial photography that a fault splay may branch westward from the main trace and could be responsible for a truncated ridge to the northwest.

## DISCUSSION AND CONCLUSIONS

*Tin Mine fault* The geomorphic expression of this fault agrees well with the mapped location of Weber (1977). Although well-expressed geomorphically, the features observed may be pre-Holocene, or could be, in part, fault line features. On the other hand, its expression is at least as strong as some of the demonstrably active faults in the area. Lateral stream offsets along this fault are comparable to offsets along the Main Street fault, although there is no control established for the relative age of these drainages. There is no indication of prominent modern compression or uplift within the left-step between the Tin Mine and Main Street faults, but this expected effect might be negated by the oblique junction with the Chino fault immediately to the east.

Based on the pattern of faulting in this area and onto the Black Star Canyon quadrangle, it appears that some slip from the Elsinore fault zone has been distributed, via the Tin Mine fault, into a series of more westerly-trending, south-dipping thrust faults, including the Fresno fault (see Figure 2). Although I see no indication of a direct near-surface connection to the Whittier fault (north of the Santa Ana River), the continuity of the northernmost Elsinore fault zone with the Whittier fault zone, perhaps at depth, has been discussed by Maher (1982) and is certainly implied by Gray and others (2002). Although no geologic studies (of record) have been done to document the activity of this fault, the role of the Tin Mine fault in connecting the Elsinore fault with the Whittier fault, as well as its comparative geomorphic expression, suggest that there is probably continued displacement on this fault, as well.

*Main Street fault* The Main Street fault is well-identified in the mapping of Weber (1977) and Heath et al (1982) and is well-located by scarps and stream offsets. It was exposed in several trenches (sites 3, 4 & 5 -- GeoSoils, Inc., 1995a,b&c, 2001a). Most of the drainage offsets are observable along the southeastern (protected) side of the canyons, but at least at Main Street Canyon a more youthful offset of the northwestern canyon margin is visible. Although fault strand nomenclature is unclear, this fault may extend southeastward as far as Bedford Canyon (note mapping at site 8, Plate I). The fault location has been modified from prior mapping based on aerial photo interpretation and trench exposures.

Northward, much of the slip along the Main Street fault may be transferring to the Chino fault (in the vicinity of sites 3 and 4; locale D) and the Tin Mine fault, but the fault still has some weak geomorphic expression along trend west of Tin Mine/Hagador canyon, and may be responsible for a slight canyon offset at locale C. Although much of this northwestern expression may be erosional, with well over 200 m dextral offset at Hagador canyon this fault strand is a likely locus of diminishing displacement in this stepover zone.

*Eagle fault* The Eagle fault is mapped by Weber (1977) and is marked by good geomorphic expression, as well as being located in trenches for several studies (sites 8, 9 & 10 – GeoSoils, Inc., 1997, 2001b,c,d,e). Although this fault does not appear to affect younger drainages in the vicinity of Joseph Canyon (locality G), it is more strongly expressed to the south and is probably active through sites 8, 9 and 10 (GeoSoils, 1997, 2001b-e). Weber's mapping is slightly relocated based on aerial photo interpretation and consulting studies. Another strand from Smith (1978, 1979) is also revised based on interpretation of aerial photos.

*Glen Ivy North fault* This fault is well-located by Weber (1977), by trenching at site 10 (Pacific Soils, Inc,. 1984) and from geomorphic expression (e.g. locale J). Although fault nomenclature is not well-established here, additional studies at site 9 (GeoSoils, Inc., 2002 – also see Field Observations) and geomorphic expression near locale I and to the northwest would appear to extend this fault (outside of the current EFZ), perhaps as far as site 8 where an unnamed fault was observed to cut surface colluvium (GeoSoils, Inc., 1997). In the area southeast of Bedford Canyon the consultants (GeoSoils, Inc., 2002 and earlier) have followed the general fault pattern interpretation (dotted and queried) of Weber (1977; also in Gray et al, 2002) as shown on Plate I. However, the strike of fault splays as observed in their trenches suggests a more consistent northwesterly trend and continuity to the fault strands as I have depicted here, in pink (Plates I or II). This interpretation puts the section of overturned bedrock (Silverado Formation) within a single fault-bounded block and is consistent with better-defined faults mapped by Weber (1977).

The Glen Ivy North fault has been shown to have had Holocene displacement less than 2 km to the southeast (Rockwell et al, 1986). The thickening of the colluvium in Pacific Soils' (1984) trench T-9 (site 10) as well as offset drainages and displaced colluvium at site 8 is also suggestive of recent movement, and there is no data to preclude Holocene activity of this northwestern portion of the fault. In consideration of its significant structural role as well as its branching relationship and proximity with the main active strand (Eagle fault) of the Elsinore fault zone it seems prudent to consider this fault active, as well.

*Glen Ivy South fault* The current EFZ extends only a few hundred meters into the Corona South quadrangle, based on stronger fault expression immediately east of this quadrangle. This fault strand is poorly located farther to the northwest. Studies by GeoSoils, Inc. (1999; site 11) purported to refute the Holocene extent of this fault on the Corona South quadrangle, based on a deep trench through Holocene and late-Pleistocene alluvium. However, the trenching was not extensive enough to preclude a stepover that is suggested by aerial photo interpretation. Available evidence is insufficient to justify modification of this zone, either larger or smaller.

## RECOMMENDATIONS (Plate III)

*Tin Mine fault* Because of the role that this fault zone must play in transferring slip between the active Elsinore and Whittier faults, the strength of geomorphic expression, and the lack of any evidence to dispute Holocene activity, this fault should be included in a new EFZ. The extension of this fault onto the Black Star Canyon quadrangle should be considered for inclusion in an EFZ when that quadrangle is further evaluated. Fault location for zoning is based on geomorphic expression.

*Main Street fault* The current zone should be modified to better fit the recently mapped fault trace and to accommodate the junction with the Chino fault, as identified in FER-247 (Treiman, 2002). It also should be extended to include the geomorphically expressed portion of this fault northwest of Hagador Canyon, as this section is part of the stepover zone to the Tin Mine fault.

*Eagle fault* The current zone should be slightly modified so as to better encompass the relocated faults of Weber (1977), as originally zoned by Smith (1978, 1979).

*Glen Ivy North fault* The current zone should be modified to include the proposed northwestern extension of the fault through sites 8, 9 and 10, and should also be modified to accommodate a slightly relocated trace near the quadrangle boundary

*Glen Ivy South fault* Current data are insufficient to warrant any modification of this zone.

10/16/02
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Table 1

Features along the Elsinore fault described by Weber (1977) on the Corona South quadrangle

PQ – pre-Quaternary; LQ – <500 ka, VQ – <25-50 ka, H – <10 ka

*[comment for this review]*

LQ-13a: paleosol is displaced
H(?)-13b: fault apparently cuts young alluvium
LQ(?)-19: older alluvium may be faulted
LQ-20: late-Quaternary (?) landslide breccia is faulted; some youthful geomorphology
LQ-21: late-Quaternary (?) landslide breccia is faulted
LQ-22: older alluvium is displaced
PQ-23: no evidence of young faulting
LQ-24: older alluvium is displaced at scarp *[scarp is not evident in photos]*
PQ-25: no evidence of Quaternary faulting
LQ-26: fault displaces older alluvium *[no fault geomorphology to eastern trace, but main trace coincides with evident lateral offset of canyon]*
PQ-27: no evidence of Quaternary faulting
VQ(?)-28: older alluvium probably displaced at scarp
LQ-29: faults apparently displace landslide breccia
LQ-30: faults displace older alluvium; scarps *[scarps not evident]*
VQ(?)-31: base of landslide appears faulted
LQ-32: mudflow breccia is faulted
H(?)-33: vegetation lineament in younger alluvium *[not visible in 1953/54 photos]*
LQ(?)-34: older alluvium is displaced; deflected and beheaded drainages
LQ-35: older alluvium is displaced; locally vertical separation >8 m
LQ-37: older alluvium is displaced
H-43: vegetation lineament and deflected drainage *[evident in photos]*
LQ-44: older alluvium is faulted
VQ-45: slightly older alluvium apparently displaced
H-46: vegetation in alluvium along fault
H-47: scarps, sags; possible offset of fan and stream channel deposits *[some features visible in 1953/54 photos]*
LQ-48: older alluvium is displaced

Table 2
Site Specific Studies

# on map summary (consultant) [AP file #]

1. A series of studies mapped faults across this parcel in varying locations based on faults and shear zones exposed in trenches. Ultimately, mapping during grading revealed a different pattern of faults that were judged to be not active. (ICG, 1987, 1990 & 1991; Neblett 1999 and 2000) (The Main Street fault is probably just southwest of the site).
2. Limited trenching within the current EFZ found no faults. (Terra Geosciences, 1994) [2772]
3. Trenches exposed the Main Street fault in one location, and constrained the fault location by its absence in other trenches. (GeoSoils, 2001a)
4. Trenches confirmed location of one to two strands of the Main Street fault. (GeoSoils, 1995b) [3071]
5. Study concurrent with site 4 located principal strands of Main Street fault. (GeoSoils, 1995c) [3072]
6. No faults found in alluvium northeast of the main trace. (Petra, 1990) [2527] (Main Street fault is probably southwest of site).
7. No faults were identified in two trenches. (Hawes, 1990) [2452] (Site appears to straddle stepover in fault zone).
8. Following several studies by other consultants and additional trenching, this study confirmed, and recommended setbacks from, two fault strands outside of the current EFZ. The western fault strands (within the current EFZ) are part of the Eagle fault and possibly a southeastern extension of the Main Street fault. The easternmost strand (a possible northwest extension of the Glen Ivy North fault) cuts up to the surface through colluvial material. (GeoSoils, 1997) [3115]
9. Trench investigation identified at least two strands of the Eagle fault. Other lineaments investigated did not indicate faulting, but trenching was not comprehensive and did not explore some of Webers (1977) lineaments and parts of the Glen Ivy North fault. (GeoSoils, 2001b,c,d,e). Subsequent investigations (GeoSoils, 2002) appear to corroborate the projection of the Glen Ivy North fault (see discussion of Field Observations).
10. Trench studies located what are probably the Eagle fault and the Glen Ivy North fault (outside of the current EFZ). The Eagle fault overrides soil and the Glen Ivy North fault offsets terrace deposits (Pacific Soils Engineering, Inc., 1984; see Figure 4) [1701]
11. Recent trench studies across the direct projection of the Glen Ivy South fault found no evidence that this strand extends northwestward (GeoSoils, 1999), but the investigation does not preclude a stepover. Earlier studies by Pacific Soils Engineering (1984) mapped the fault trace further to the northwest, as did Weber (1977) but in a different location. [1701]

Table 3
Locales discussed in text

A. A probable late-Pleistocene or Holocene channel of Fresno Canyon has been beheaded, possible as a result of lateral offset and uplift along the Tin Mine fault.
B. Mabey Canyon and an unnamed canyon to the south are each right-laterally deflected or offset (400-500 m for Mabey Canyon and 160-170 m for the other).
C. The northwestern extension of the Main Street fault appears to offset an unnamed drainage approximately 30-40 m, although this tentative offset may also be related to the slightly more northerly trending fault.
D. The interaction of the Elsinore and Chino faults at this locale have resulted in uplift of the terrain between the two faults. Dextral offset is evident where the Main Street fault has offset the east margin of Hagador Canyon about 230 m, with a similar offset of an unnamed canyon to the east.
E. There is an approximately 30 m right-lateral offset of the west margin of Main Street Canyon. The west margin, downstream of the fault, would be subject to more active erosion, and the preservation of this feature implies that this may represent a younger displacement.
F. The east margin of Eagle Canyon is offset about 200 m at the Main Street fault. The next drainage to the southeast (Joseph Canyon) is deflected at least 400 m as it drains around a possible shutter ridge.
G. The Eagle fault does not clearly affect any of the drainages in this locale.
H. The active wash in Bedford Canyon broadens as it crosses the fault zone, with most of the widening appearing to be on the southeast margin, indicating dextral offset in excess of 100 m. The offset may occur across both the Eagle fault and the inferred northwestern extension of the Glen Ivy North fault.
I. The Glen Ivy North fault appears traceable northwestward to at least this locale, based on trenches and possible scarps. This southeastward flowing portion of McBribe Canyon may be fault controlled. The fault may continue to connect with another fault strand northwest of Bedford Canyon.
J. The east margin of Brown Canyon is offset 70-80 m at the Glen Ivy North fault

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## AERIAL PHOTOGRAPHS USED

| | | | | |
|---|---|---|---|---|
| Fairchild | b/w 7x9 | 1”=1320’ | flight C-1740 | 9/19/1931 |

frames 208-210, 244-247, 317-319, 346-348, 372-373, & 392

| | | | |
|---|---|---|---|
| USDA | b/w 9x9 | 1:20,000 | 1953-1954 |
| AXM-6K | frames | 78-83 | 9/22/53 |
| AXM-6K | | 127-128 | 9/23/53 |
| AXM-7K | | 2-4 | 9/23/53 |
| AXM-7K | | 26-31 | 9/23/53 |
| AXM-7K | | 44-48 | 9/23/53 |
| AXM-15K | | 139-143 | 12/31/53 |
| AXM-15K | | 191-193 | 1/05/54 |

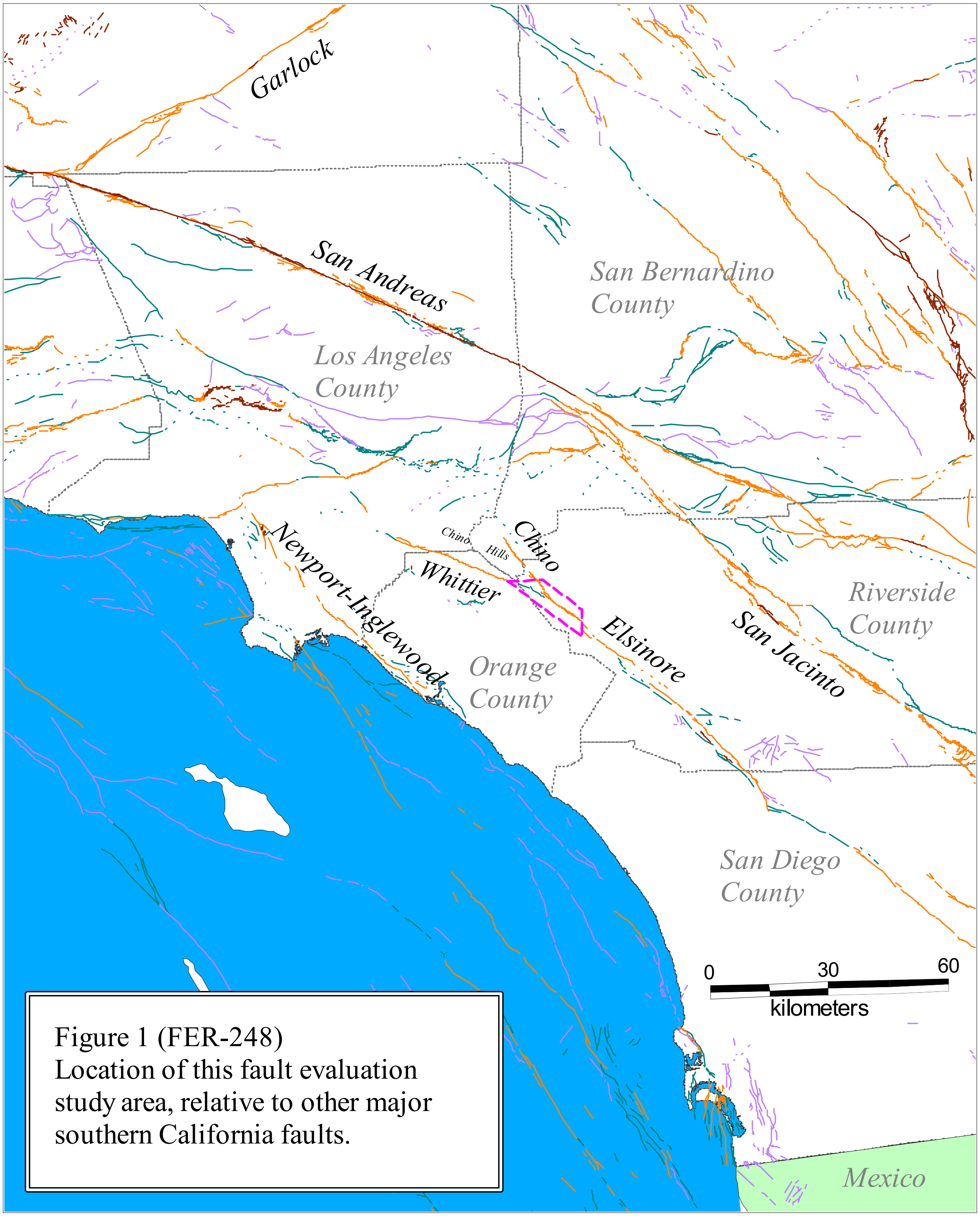


Figure 1 (FER-248)
Location of this fault evaluation study area, relative to other major southern California faults.

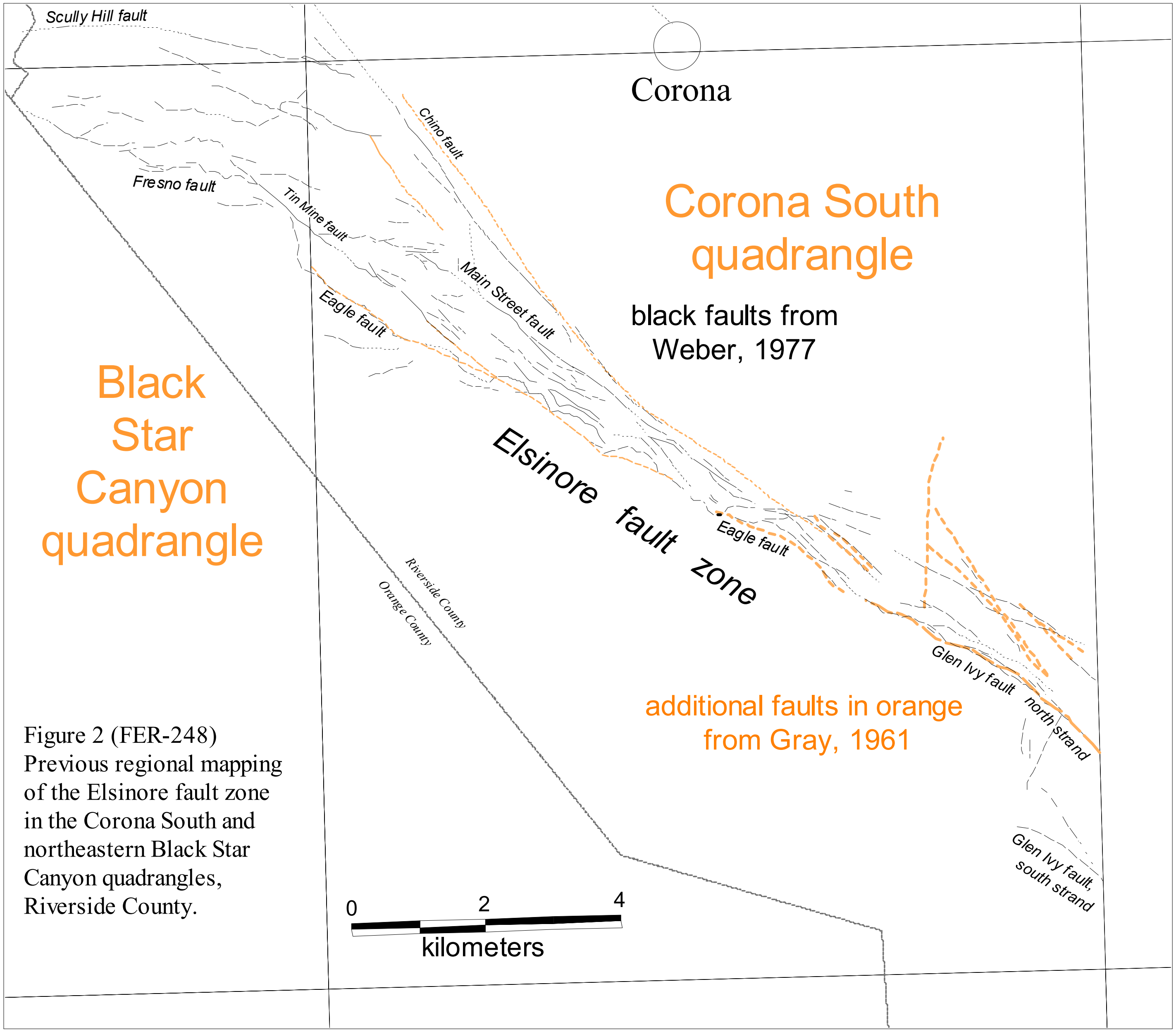


Figure 2 (FER-248)
Previous regional mapping of the Elsinore fault zone in the Corona South and northeastern Black Star Canyon quadrangles, Riverside County.